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EXTENT, LOCATION AND ESTIMATED OIL CONTENT OF OIL SHALE DEPOSITS IN THE UNITED STATES

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By Donald C. Duncan

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UNITED STATES DEPARTMENT OF THE INTERIOR

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By Donald C. Duncan
U. S. Geological Survey, Washington, D. C.

More than 200 black shale and organic-rich shale deposits are known in the United States. Only limited information is available as to the potential energy yield or oil yield of most of them, but deposits that have been partly appraised include: 1) large high-grade oil shale deposits of Tertiary age in the central Rocky Mountain Region, 2) large low-grade black marine shale deposits in the eastern and central states, and 3) numerous small carbonaceous shale deposits associated with coal-bearing rocks. Miscellaneous other organic-rich shales, including deposits in Alaska, California, and Montana, contain some high-grade oil shale. They have not been studied in detail, although a rough estimate of their size is included in the estimate of potential resources shown in table 1. The general location of the prinicpal known deposits is shown in the accompanying map, figure 1.

Tertiary oil shale of the Rock Mountain Region

The largest and highest grade oil shale deposits known in the country are in adjoining parts of northwestern Colorado, northeastern Utah, and southwestern Wyoming (see figure 2). In this region oil shale-bearing rocks of the Green River Formation of Eocene age underlie a total area of about 16,000 square miles. Only 500 to 600 square miles of the more accessible part of the deposits have been explored and tested by core

Table 1.--Potential shale oil resources in the United States (billions of barrels of oil equivalent in place)

	Known deposits		Unexplored deposits		
	Shale yielding 25 gal. or more per ton	Shale yielding 10 to 25 gal. per ton	Shale yielding 25 gal.	Shale yielding 10 to 25 gal. per ton	Shale yielding 5 to 10 gal. per ton
Tertiary oil shale					
Rocky Mountains	650	1,150	650	1,350	3,000
California	--	--	--	70	?
Mesozoic shale					
Alaska	--	--	200	200	large
Devonian-Mississippian shale (Eastern and central states)	--	--	--	1,050	1,800
Shale associated with coal	--	--	60	260	210
	650	1,150	910	2,930	5,010
Other undiscovered and unappraised deposits				14,000	95,000
Grand total of potential resources				20,000	100,000

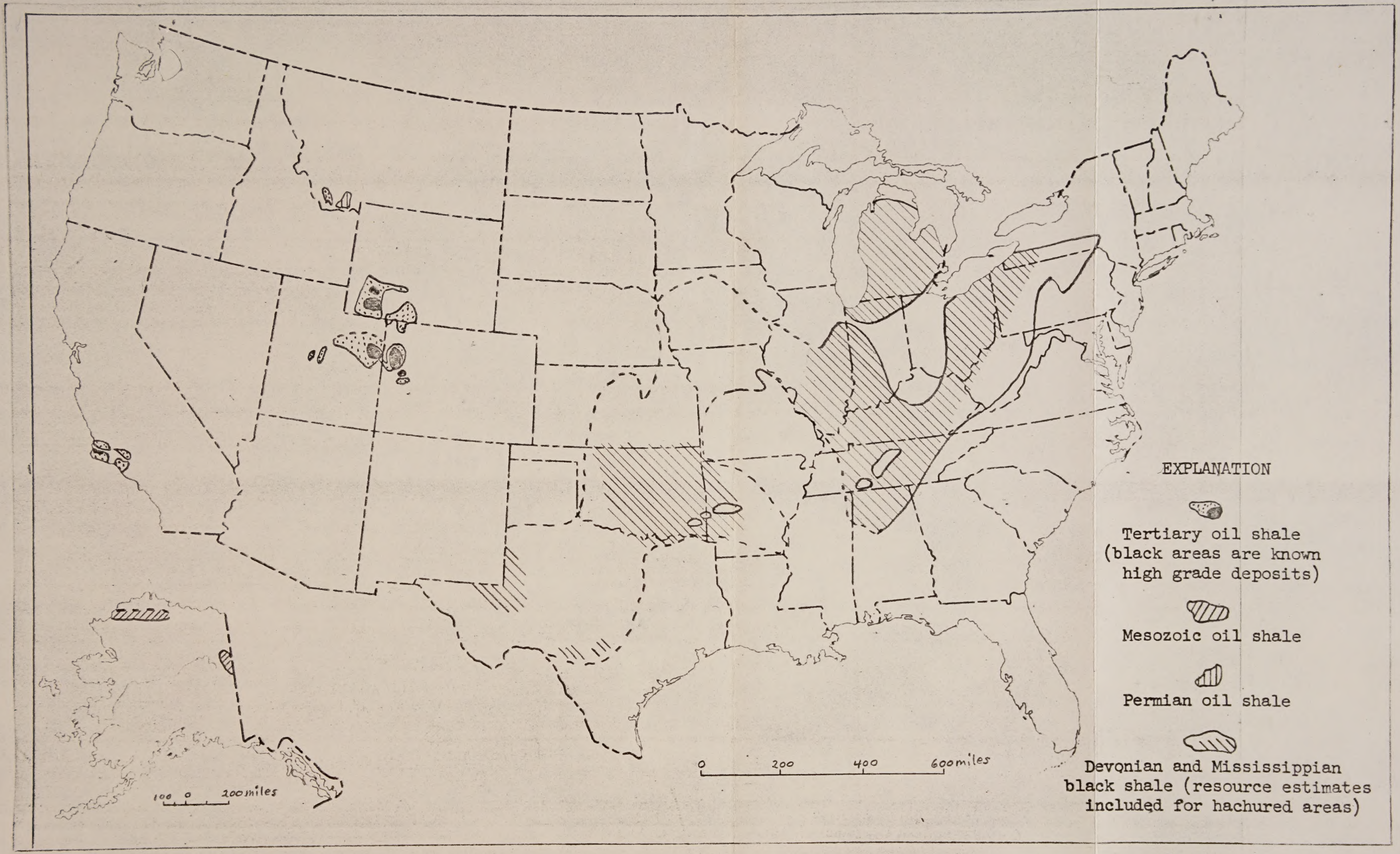
EXPLANATION
Tertiary oil shale (black areas are known high grade deposits)
Mesozoic oil shale
Permian oil shale
Devonian and Mississippian black shale (resource estimates included for hachured areas)
0 200 400 600 miles
100 0 200 miles

Figure 1.- Distribution of principal oil shale deposits in the United States

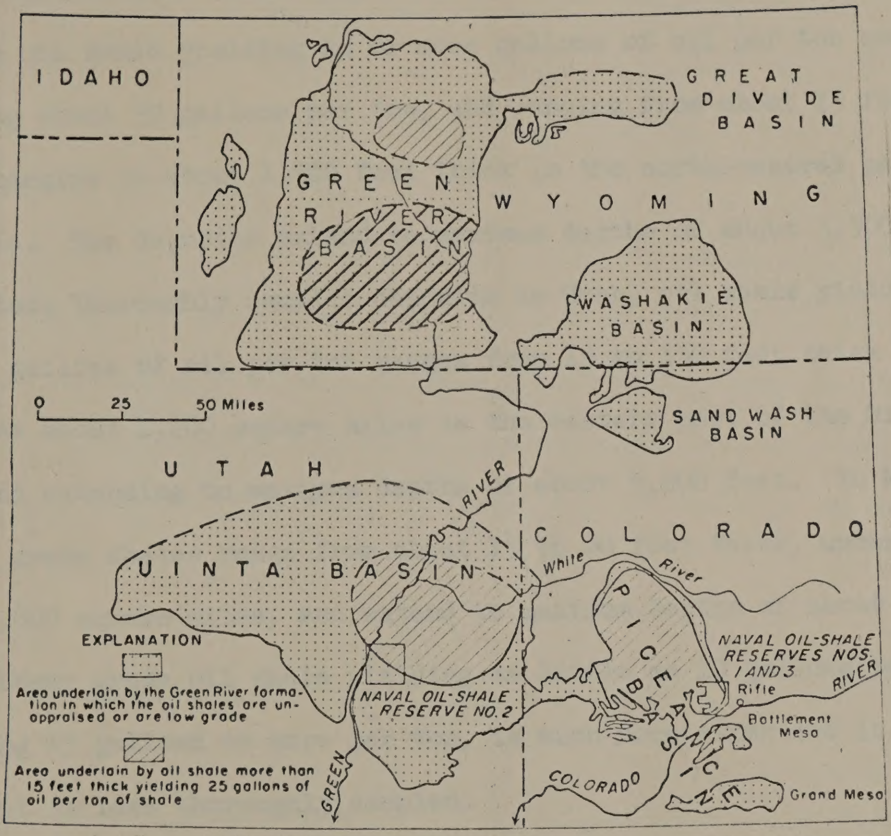
IDAHO
GREAT DIVIDE BASIN
GREEN RIVER BASIN
WYOMING
WASHAKIE BASIN
SAND WASH BASIN
0 25 50 Miles
UTAH
RIVER
COLORADO
UINTA BASIN
White River
PICEANCE BASIN
EXPLANATION
Area underlain by the Green River formation in which the oil shales are unappraised or are low grade
Area underlain by oil shale more than 15 feet thick yielding 25 gallons of oil per ton of shale
NAVAL OIL-SHALE RESERVE NO. 2
NAVAL OIL-SHALE RESERVES NOS. 1 AND 3
Rifle
RIVER
Battlement Mesa
GREEN
COLORADO
Grand Mesa

Figure 2.--Principal oil shale deposits of the Green River Formation of Tertiary age

drilling in sufficient detail to plan development, but the approximate oil content of large parts of the deposits are known from analyses of rotary drill cuttings obtained incidental to petroleum and natural gas exploration of the region.

In the Piceance Creek Basin, Colorado, a 1,200-square mile area contains oil shale yielding 25 or more gallons of oil per ton and averaging about 30 gallons per ton, and ranging from about 15 feet thick at the margins to about 1,500 feet thick in the north-central part of the basin. The deposits extend to maximum depths of about 3,500 feet. In the less thoroughly sampled deposits in Utah, oil shale yielding 25 or more gallons of oil per ton ranges from 15 to 150 feet thick and underlies about 1,200 square miles in the eastern part of the Uinta Basin and extending to maximum depths of about 5,000 feet. In Wyoming, similar grade shales range from about 15 to 80 feet thick, underlie about 1,800 square miles, and extend to maximum depths of about 3,000 feet. Lower grade oil shale yielding as little as 10 gallons per ton, and averaging 15 gallons or more per ton, is much more extensive in the above areas but is less thoroughly sampled.

Known deposits in the Piceance Creek Basin, Colorado, are estimated to contain about 500 billion barrels of oil equivalent in the higher grade shale yielding 25 gallons or more oil per ton and averaging about 30 gallons per ton, and about 500 billion barrels additional in shale yielding more than 10 gallons of oil per ton. Possible undiscovered deposits in Colorado might contain an additional 100 billion barrels in the richer oil shale and 200 billion barrels in the lower grade shale.

Known resources in the Uinta Basin, Utah, contain about 120 billion barrels of oil equivalent in shale yielding more than 25 gallons of oil per ton; and about 500 billion barrels in shale yielding more than 10 gallons per ton. Undiscovered or unexplored resources in Utah are estimated to contain about 500 billion barrels in higher grade shale, possibly 1,000 billion barrels more in shale containing more than 10 gallons per ton, and possibly 3,000 billion barrels in shale yielding about 5 to 10 gallons per ton.

Known resources in the Green River Basin, Wyoming, include about 30 billion barrels in shale yielding 25 gallons or more oil per ton and about 150 billion barrels in shale yielding more than 10 gallons per ton. Undiscovered resources in Wyoming might contain about 50 billion barrels in higher grade deposits, and 150 billion barrels in the lower grade deposits.

Devonian and Mississippian black shales, eastern and central states

The Devonian and early Mississippian black shales are perhaps the most widespread organic-rich shale deposits in the country. Their general distribution, with omission of deposits in some western states, is shown in figure 1. These deposits range from a few feet to several hundred feet in thickness and contain 5 to 25 percent organic matter. By direct combustion they yield 1 to 7 million Btu per ton of shale. If processed by conventional distillation methods, however, they yield 5 to 15 gallons of oil per ton, and if processed by hydrogenolysis they may yield 800 to 1,650 cubic feet of high Btu gas per ton of rock.

Preliminary studies of the potential energy, oil or gas yield of the deposits have been made at scattered localities in Kentucky, Tennessee, Illinois, Kansas, Indiana, Ohio, Oklahoma, and Texas. Parts of the deposits yielding 10 gallons or more oil per ton, in zones 5 feet or more thick, and extending to depths less than 5,000 feet, are estimated to contain on the order of about 1,050 billion barrels oil equivalent; parts yielding 5 to 10 gallons per ton are estimated to contain on the order of about 1,800 billion barrels. If the same parts of the deposits were processed to produce gas by hydrogenolysis, the potential gas yield would be 7,800 trillion cubic feet from the richer shale and 12,700 trillion cubic feet from the leaner shale.

Selected deposits in other areas

Extensive oil shale deposits are known from reconnaissance studies in eastern and northern Alaska (see figure 1). Deposits of marine Triassic oil shale in eastern Alaska, yielding 25 gallons or more oil per ton, are thought to contain about 200 billion barrels of oil equivalent. Deposits of Triassic, Jurassic, and Cretaceous shales north of the Brooks Range are thought to contain an additional 200 billion barrels in shales yielding 10 to 100 gallons of oil per ton.

Extensive oil shale deposits in the Monterey Formation of Miocene age are reported in southern California. A. C. Rubel, in 1955, estimtated that deposits underlying about 3,070 square miles, and yielding 3 to 30 gallons of oil per ton, contain about 70 billion barrels of oil equivalent.

Low-grade marine oil shale deposits of Permian age are reported in southwestern Montana. Locally the shales yield about 10 gallons of oil per ton in units 10 to 20 feet thick, and underlie about 600 square miles of the region. Somewhat higher grade oil shales in Tertiary lake basins are reported to underlie approximately 280 square miles in southwestern Montana.

Numerous other marine and lacustrine organic-rich shales are known to yield oil in varying amounts but data as to thickness, extent, and potential oil yield of the individual deposits are too incomplete for specific appraisal.

Carbonaceous shales associated with coal

Numerous cannel shale deposits yielding 25 to 50 gallons of oil per ton of shale are known in the coal fields of the Appalachian and Interior Provinces (see figure 3). Such individual high-grade deposits are generally small with oil contents of a half million to a few million barrels in rock in place. Known resources in a small number of deposits in Pennsylvania and West Virginia were estimated by Winchester in 1928 to contain about 27 million barrels of oil. Lower grade carbonaceous shales yielding 10 to 25 gallons of oil per ton, ranging from a few feet to about 10 feet thick, are widely distributed in Illinois, Indiana, Kansas, Oklahoma, and Kentucky. Other deposits are reported in Texas and Utah, although the carbonaceous shales in the coal fields of the western states and Alaska are mostly unstudied for their potential oil yield. Based on sparse statistical data estimates of the approximate magnitude of the oil content of the unappraised or undiscovered carbonaceous shales associated with coal in the United States are shown below:

Shale yielding 25 to 50 gallons of oil per ton	60 billion barrels
Shale yielding 10 to 25 gallons of oil per ton	260 billion barrels
Shale yielding 5 to 10 gallons of oil per ton	210 billion barrels

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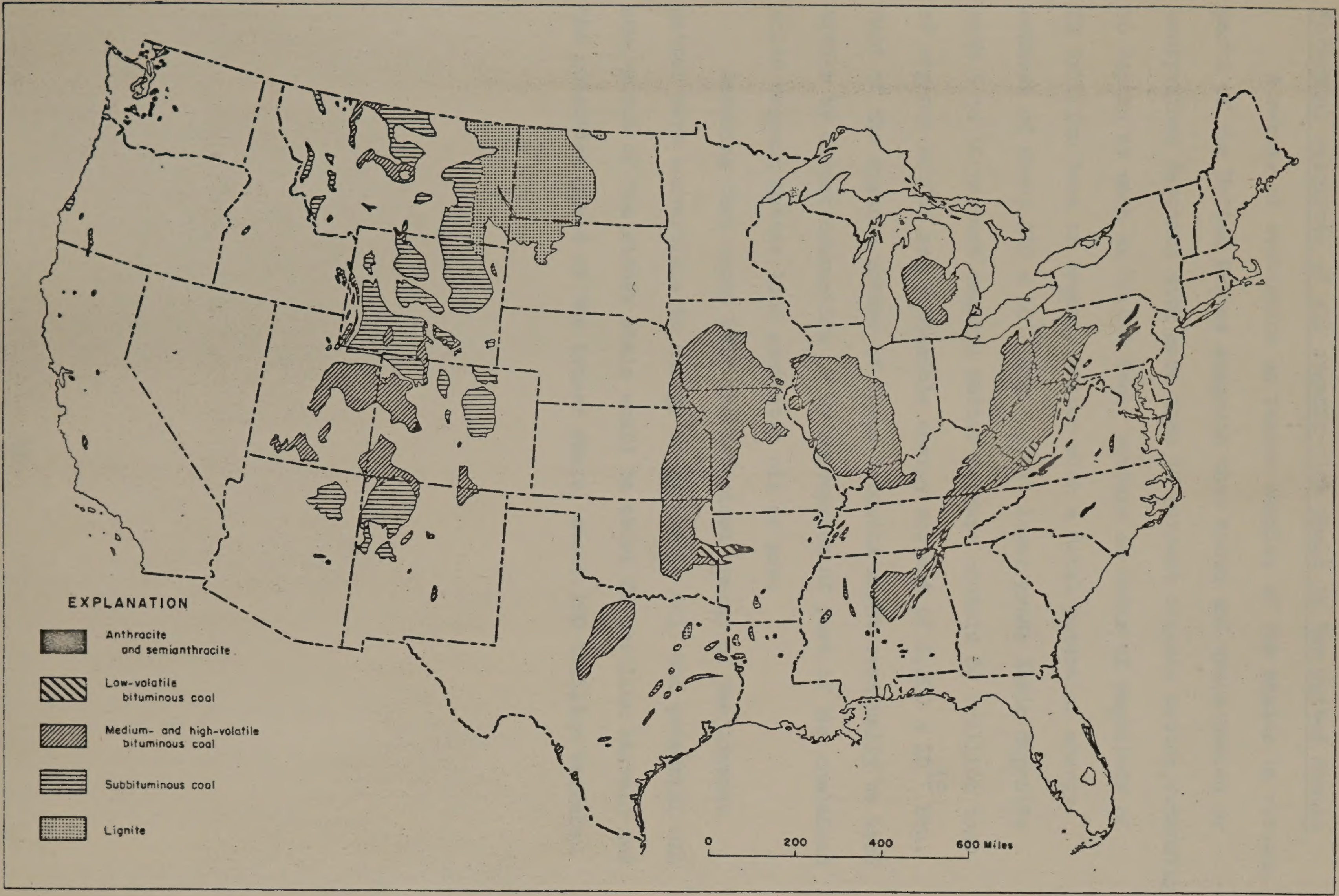
EXPLANATION
Anthracite and semianthracite
Low-volatile bituminous coal
Medium- and high-volatile bituminous coal
Subbituminous coal
Lignite
0
200
400
600 Miles

Figure 3.--Coal fields of the conterminous United States

Potential resources of all organic-rich shale in the United States

A review of statistics on random samples of the shales in various parts of the United States suggests that known and undiscovered or unappraised deposits with more than 10 percent organic matter, extending to depths as much as 20,000 feet, contain an order of magnitude of 12 trillion tons of organic matter with a total potential energy content of about 240 x 10^{18} Btu. Still lower grade shale deposits with 5 to 10 percent organic matter perhaps contain 60 trillion tons of organic matter and a possible energy content of 1,200 x 10^{18} Btu. Part of the organic matter of these deposits might eventually be used either by direct combustion or by conversion of part of the contained solid organic matter into synthetic oil or gas.

Assuming that about half the contained energy of the organic matter were convertible to energy in synthetic oil, the potential oil equivalent of the richer shale would be about 20 trillion barrels and the potential yield of the leaner shale, about 100 trillion barrels.